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Issues in the diagnosis of hypothermia: A comparison of two geographically separate populations

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ABSTRACT

A review of hypothermic deaths was undertaken using cases from the Charité University, Berlin, Germany and Forensic Science South Australia, Australia. There were 16 cases from Berlin (age range 38–96 years; average 68 years; M:F = 13:3) Wischnewski spots were present in all 16 cases (100%), skin discolouration in nine (56%), and acute pancreatitis and muscle haemorrhage in one case each (6%). There were 62 Australian cases (age range 30–89 years; average 67 years; M:F = 13:18). Wischnewski spots were present in 57 (92%), skin discolouration in seven (11%), vacuolization of renal cells in six (10%), and acute pancreatitis in one (2%). Reporting of the pathological findings in hypothermia may vary among jurisdictions influenced by the location and nature of these deaths and also by reliance on particular features to make the diagnosis. In addition, it is possible that the aetiology of these markers is quite complex and involves not only a significant reduction in core temperature, but the variable and poorly-understood interaction of a number of other factors.

1. Introduction

Hypothermia occurs when the core temperature of the body drops below 35 °C, with fatalities resulting from cardiac arrhythmias due to myocardial ischaemia and/or hypoxia associated with electrolyte imbalances and the effects of catecholamines. This begins at around 26–29 °C.[1,2] Despite profound physiological changes, the pathological markers of hypothermia at autopsy may be subtle and inconsistent. Thus, the diagnosis of lethal hypothermia may rely upon consideration of other factors, such as the circumstances of the death, and the death scene findings.[3,4] The following study was undertaken to look at pathological findings identified at autopsy and diagnostic issues that arise by comparing cases of lethal hypothermia in two geographically separate centres, Berlin, Germany and Adelaide, South Australia.

2. Materials and methods

Case files of deaths attributed to hypothermia between 1st of January 2006 and 31st of December 2011, were obtained from the Institute of Legal Medicine and Forensic Sciences at the Charité University, Berlin, Germany and from Forensic Science South Australia, Adelaide, Australia using an electronic search for the term 'hypothermia'. Cases in which hypothermia was identified as a primary cause of, or a contributing factor to, death, in which positive pathological findings for hypothermia were documented, were included in the study. Cases in which hypothermia was only suspected, but where no pathological features were present, were excluded from the study, except where the circumstances of death were strongly suggestive of lethal hypothermia. Review and analysis included the following parameters; age, sex, place of discovery, underlying medical conditions and pathological findings. All cases were de-identified following review and analysis. The cases from Adelaide included all medicolegal autopsies from South Australia over the time of the study.

3. Results

3.1. Berlin

There were 16 cases of fatal hypothermia: age range 38–96 years; average 68 years; M:F = 13:3. Twelve deaths (75%) occurred indoors, and four (25%) outdoors. Associated risk factors were

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identified in seven cases (44%) consisting of alcoholism (19%), dementia (13%), Parkinson disease (13%), diabetes mellitus (6%), epilepsy (6%) and homelessness (13%). There were four cases of paradoxical undressing and four cases of Diogenes syndrome. Pathological evaluation revealed Wischnewski spots in 16 cases (100%), with one case having mucosal lesions in both the stomach and duodenum, discolouration of skin over the major joints in nine cases (56%), and acute pancreatitis and psoas muscle haemorrhage in one case each (6%).

3.2. Adelaide

There were 62 cases of fatal hypothermia: age range 30–86 years; average 67 years; M:F = 13:18. Fifty-two deaths (84%) occurred indoors, and 10 (16%) outdoors. Associated risk factors were identified in 56 cases (90%) and included cardiovascular disease (60%), mental illness (23%), previous cerebrovascular incident (8%), alcohol and drug use (15%; 10%), diabetes (18%), cancer (8%), arthritis (11%), hepatitis (6%), renal (6%) and liver disease (5%). (A detailed review of the epidemiological features of these cases is in press[5]). Pathological evaluation revealed Wischnewski spots in 57 cases (92%), with discolouration of skin over the major joints in seven cases (11%), basal vacuolization of renal tubular epithelial cells in six cases (10%), and acute pancreatitis in one case (2%) (Table 1).

4. Discussion

Autopsy findings in cases of fatal hypothermia may be characteristic but are not diagnostic. Features that occur include superficial lesions of the gastric mucosa, pinkish discolouration of skin over the major joints, acute pancreatitis with fat necrosis, fatty changes of the heart, liver and kidneys, vacuolisation of renal tubular cells and haemorrhage within muscles. The causes and mechanisms of these changes are, however, not well understood.[3,4,6,7]

The finding that has been considered the most reliable marker for hypothermia at autopsy is patchy discolouration of the gastric mucosa in the form of Wischnewski spots. These lesions consist of focal areas of intramucosal haemorrhage with subsequent ulceration.[8] Their aetiology remains unclear and they may arise following disturbances in microcirculation with ischaemic-reperfusion injury.[4,7] While the incidence of Wischnewski spots in the present study was 92% (Adelaide) and 100% (Berlin), it has been as low as 44% in other reports[9–13] (Table 2).

The lower rates in some studies may suggest that Wischnewski spots do not always occur with lethal hypothermia. While animal studies have produced these lesions, it has been shown that reducing stress levels in chilled animals, decreased both the size and number of gastric lesions, possibly associated with reduced gastric acid secretion[14]; similarly in a stress-reduced hypothermic animal model developed by the authors Wischnewski spots actually failed to develop.[15] Conscious animals have also developed more severe gastric injury compared to animals that were anaesthetized.[16] These studies may indicate that the development of these lesions depends on additional factors, including stress.

Table 1
Pathological features of hypothermic deaths in Adelaide and Berlin.

Pathological features	Adelaide		Berlin	
	Number	%	Number	%
Wischnewski spots	57	92	16	100
Discolouration of extremities	7	11	9	56
Renal vacuolization	6	10	–	–
Acute pancreatitis	1	2	1	6
Muscle haemorrhage	–	–	1	6

Table 2
Reported incidence of Wischnewski spots in cases of lethal hypothermia.

	Year	Frequency (%)
Current study (Berlin)	2012	100%
Current study (Adelaide)	2012	92%
Wischnewski[13]	1895	90.9%
Takada et al.[12]	1991	88%
Mant[11]	1969	86%
Birchmeyer & Mitchell[10]	1989	60%
Mizukami et al.[9]	1999	44%

Another issue that arises in determining the true incidence of Wischnewski spots is the possibility of diagnostic bias; i.e. if the diagnosis of hypothermia is only made when the spots are present then the incidence of the gastric lesions would be expected to be 100%. This is much more likely to occur in situations where hypothermia is not obvious from the scene findings and the diagnosis relies more heavily on autopsy findings. As the majority of hypothermic deaths occur indoors in Berlin and Adelaide, this may suggest that there is a risk of under-diagnosis if the scene findings did not indicate hypothermia to the investigating police officers, and the spots were absent at autopsy. This contrasts with much more obvious situations where, for example, a skier is found outside buried in snow, as the diagnosis of hypothermia would rely more on the circumstances and less on pathological markers. Given that older individuals were the most vulnerable group in this study, it is also possible that subtle hypothermic deaths may instead be attributed to the significant co-morbidities that exist in the elderly, as these would provide plausible alternative diagnoses. Thus, if Wischnewski spots are present in only half of hypothermic deaths[9,10] then the true numbers from Adelaide and Berlin may be as much as twice that recorded.

While basal vacuolization of renal tubular epithelial cells (in recent years incorrectly termed Armanni-Ebstein phenomenon)[17] has been put forward as a marker of hypothermia that may be as sensitive as Wischnewski spots,[3] the situation may be slightly more complex. Specifically, as basal vacuolization is a marker of ketoacidosis, it is probable that in some cases of hypothermia both the lowered body temperature and basal vacuolization are markers of diabetic ketoacidosis rather than both being due to exposure to low environmental temperatures.[18] In the present study 10% of the cases from Adelaide had these renal tubular epithelial changes, with none reported in the material from Berlin. Additional pathological findings also showed some variability in occurrence. These included discolouration of the extremities (Adelaide 11%; Berlin 56%), acute pancreatitis (Adelaide 2%; Berlin 6%), and muscle haemorrhage (Berlin 6%).

Limitations of the present study include its retrospective nature and relatively low number of cases. However, given this caveat, it appears that the reporting of autopsy findings in hypothermic deaths may vary among jurisdictions. This may be influenced by a number of factors that include the location and nature of these deaths, and the reliance that is placed on finding particular features to make the diagnosis. In addition, it is possible that that the aetiology of these markers is quite complex and involves not only a significant reduction in core temperature but a number of other inter-relating mechanisms. The sensitivity and specificity of Wischnewski spots as a marker for lethal hypothermia is also yet to be determined.

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Conflict of interest
None.

References

1. Turk EE. Hypothermia. *Forens Sci Med Pathol* 2010;**6**:106–15.
2. Dettmeyer RB. Hypothermia. In: *Forensic histopathology*. Berlin-Heidelberg: Springer; 2011. pp. 165–71.
3. Preuβ J, Thierauf A, Dettmeyer R, Madea B. Wischnewsky's spots in an ectopic stomach. *Forensic Sci Int* 2007;**169**:220–2.
4. Madea B, Tsokos M, Preuβ J. Morphological findings, their pathogenesis and diagnostic value. *Forensic Pathol Rev* 2008;**5**:3–21.
5. Bright F, Winskog C, Walker M, Byard RW. A comparison of hypothermic deaths in South Australia compared to Sweden. *J Forensic Sci* 2013 [in press].
6. Prahlow J, Byard RW. *An atlas of Forensic pathology*. New York: Springer Publishers; 2012.
7. Tsokos M, Rothschild M, Madea B, Risse M, Sperhake JP. Histological and immunohistochemical study of Wischnewsky spots in fatal hypothermia. *Am J Forensic Med Pathol* 2006;**27**:70–4.
8. Bright F, Winskog C, Byard RW. Wischnewski spots and hypothermia: sensitive, specific, or serendipitous? *Forensic Sci Med Pathol* 2013;**9**:88–90.
9. Mizukami H, Shimizu K, Shiono H, Uezono T, Sasaki M. Forensic diagnosis of death from cold. *Leg Med* 1999;**1**:204–9.
10. Birchmeyer MS, Mitchell EK. Wischnewski revisited: the diagnostic value of gastric mucosa ulcers in hypothermic deaths. *Am J Forensic Med Pathol* 1989;**10**:28–30.
11. Mant AK. Autopsy diagnosis of accidental hypothermia. *J Forensic Sci* 1969;**16**:126–9.
12. Takada M, Kusano I, Yamamoto H, Shiraishi T, Yatani R, Haba K. Wischnewsky's gastric lesions in accidental hypothermia. *Am J Forensic Med Pathol* 1991;**12**:300–5.
13. Ehlrich E. Wischnewski's spots. A new sign of death from hypothermia. The translated text of the original Russian article from 1885. In: Oehmichen M, editor. *Hypothermia. Clinical, pathomorphological and forensic features*, **31**. Lübeck: Res leg med Schmidt-Römhild; 2004. pp. 205–10.
14. Vincent GP, Paré WP, Prenatt JED. Aggression, body temperature and stress ulcer. *Physiol Behav* 1984;**32**:265–8.
15. Bright F, Winskog C, Walker M, Byard RW. Are Wischnewski spots always present in lethal hypothermia? The results of testing a stress-reduced animal model. *J Forensic Leg Med* 2013;**20**:785–7.
16. Landeira-Fernandez J. Analysis of the cold-water restraint procedure in gastric ulceration and body temperature. *Physiol Behav* 2004;**82**:827–33.
17. Zhou C, Yool A, Nolan J, Byard RW. Armanni-Ebstein: a need for clarification. *J Forensic Sci* 2013;**58**(Suppl. 1):S94–8.
18. Zhou C, Byard RW. Armanni–Ebstein phenomenon and hypothermia. *Forensic Sci Int* 2011;**206**:e82–4.